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PRE-RECONNAISSANCE INVESTIGATION OF ENVIRONMENTAL CONTAMINANTS ASSOCIATED WITH IRRIGATION DRAINWATER AT THE UMATILLA NATIONAL WILDLIFE REFUGE, UMATILLA COUNTY, OREGON 1989

Carol A. Schuler
U.S. Fish and Wildlife Service
Oregon State Office
Portland, Oregon

John Annear
U.S. Fish and Wildlife Service
Umatilla National Wildlife Refuge
Umatilla, Oregon

Elizabeth J. Materna
U.S. Fish and Wildlife Service
Oregon State Office
Portland, Oregon

Portland, Oregon
1993

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PRE-RECONNAISSANCE INVESTIGATION OF ENVIRONMENTAL CONTAMINANTS ASSOCIATED WITH IRRIGATION DRAINAGE AT THE UMATILLA NATIONAL WILDLIFE REFUGE, UMATILLA COUNTY, OREGON 1989

Carol Schuler, John Annear, and Elizabeth Materna

ABSTRACT

The Umatilla National Wildlife Refuge (refuge) was selected for a pre-reconnaissance investigation because of potential hazards associated with irrigation drainage in the Umatilla Drainwater Project Area. The refuge is surrounded by agricultural lands noted for intensive crop production and heavy use of chemical pesticides which may enter the refuge via ground and surface water runoff. To determine the potential for irrigation drainage water to adversely affect fish and wildlife populations, water, sediment, invertebrate, fish, and bird samples were collected and analyzed for trace elements; organochlorine, organophosphate, and carbamate pesticides; and polychlorinated biphenyls. In addition, several acute and chronic toxicity tests were performed on water and sediment collected from the refuge. Results show concentrations of analytes were below published effect levels. No mortality or effects were noted in toxicity tests with water and sediments. Results of this pre-reconnaissance survey do not show the presence of hazardous concentrations of inorganic or organic compounds, albeit results of this pre-reconnaissance study are limited. A potential hazard to fish and wildlife may continue to exist due to the extensive use of pesticides near the refuge. However, more extensive testing would be needed to determine if pesticide use poses a significant threat to fish and wildlife.

INTRODUCTION

Background

During the last several years, there has been increasing concern about the quality of irrigation drainage and its potentially harmful effects on human health, fish, and wildlife. Concentrations of selenium exceeding water-quality criteria for the protection of aquatic life (U.S. Environmental Protection Agency 1986) have been detected in subsurface drainage from irrigated land in the western part of the San Joaquin Valley in California. In 1983, incidents of mortality, birth defects, and reproductive failures in waterfowl were discovered by the U.S. Fish and Wildlife Service at the Kesterson National Wildlife Refuge in the western San Joaquin Valley, where irrigation drainage was impounded. In addition, potentially toxic trace elements and pesticides have been detected in other areas in Western States that receive irrigation drainage.

Because of concerns expressed by the U.S. Congress, the Department of the Interior started a program in late 1985 to identify the nature and extent of irrigation-induced water-quality problems that might exist in the Western States. A pre-reconnaissance investigation is directed toward providing a preliminary evaluation as to whether irrigation drainage could potentially cause harmful effects on fish and wildlife or adversely affect the suitability of water for other beneficial uses.

The Umatilla National Wildlife Refuge (refuge) was selected for a pre-reconnaissance investigation because of potential hazards associated with irrigation drainage in the

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Umatilla Drainwater Project Area. The Umatilla Drainwater Project area is noted for its intensive crop production and heavy use of agricultural pesticides. The refuge is located in the Project Area and is surrounded by agricultural lands. The refuge is positioned downslope from numerous farming operations and is exposed to agricultural runoff via ground and surface water. Common crops grown in the area include alfalfa, potatoes, corn, apples, peaches, pears, and wheat. The majority of these crops are grown under an intensive regimen of pesticide applications to control a variety of insects, fungi, plants, and rodents. Additionally, other chemicals are used to promote growth or approve product appearance. The chemical formation of pesticides used in this area include organochlorines, organophosphates, carbamates, and chlorophenoxy acid herbicides.

Agricultural runoff from surrounding farming operations could potentially expose the refuge to hazardous concentrations of agricultural pollutants. Thus, a potential exists for irrigation drainwater to adversely affect fish and wildlife using the refuge.

Purpose and Scope

This report presents results of a pre-reconnaissance investigation of the refuge in 1989 to determine the potential for irrigation drainage water to adversely affect fish and wildlife populations and other beneficial water uses. The purpose of the pre-reconnaissance study was to provide preliminary evidence to determine whether a sufficient threat exists to warrant proceeding with a full reconnaissance level investigation. To evaluate potential environmental threats, samples of water, sediments, invertebrates, fish, and birds were collected from the refuge. These samples were analyzed for trace elements; organochlorine, organophosphate, and carbamate pesticides; and polychlorinated biphenyls. In addition, several acute and chronic toxicity tests were performed on water and sediment collected from the refuge. These concentrations were compared with various water-quality standards or criteria, published literature values, and data from other areas.

Acknowledgements

The authors wish to thank the Manager of the Umatilla NWR, Morris LeFever, and refuge biologists, for providing logistical and field support. Field assistance was appreciated from Dave Sill and refuge biologists. Appreciation is extended to Susan Burch and Carmen Thomas for their work on summarizing the data and to Larry Rassmussen for providing information on area resources.

DESCRIPTION OF THE UMATILLA NATIONAL WILDLIFE REFUGE

Description of the Refuge

The Umatilla National Wildlife Refuge is located in the lower portion of the Columbia Basin (figure 1). The refuge is situated 263 miles upstream from mouth of the Columbia River and it stretches over 22 miles of both shoreline and uplands on the Oregon and Washington sides of the river. This refuge is slightly less than 23,000 acres in size and about 45 percent of the acreage is the river's open water or its backwaters. The wildlife refuge, which is superimposed on U.S Army Corps of Engineers land, was officially established in 1969 to provide mitigation for wildlife habitat lost when the pool behind the John Day Dam was filled.

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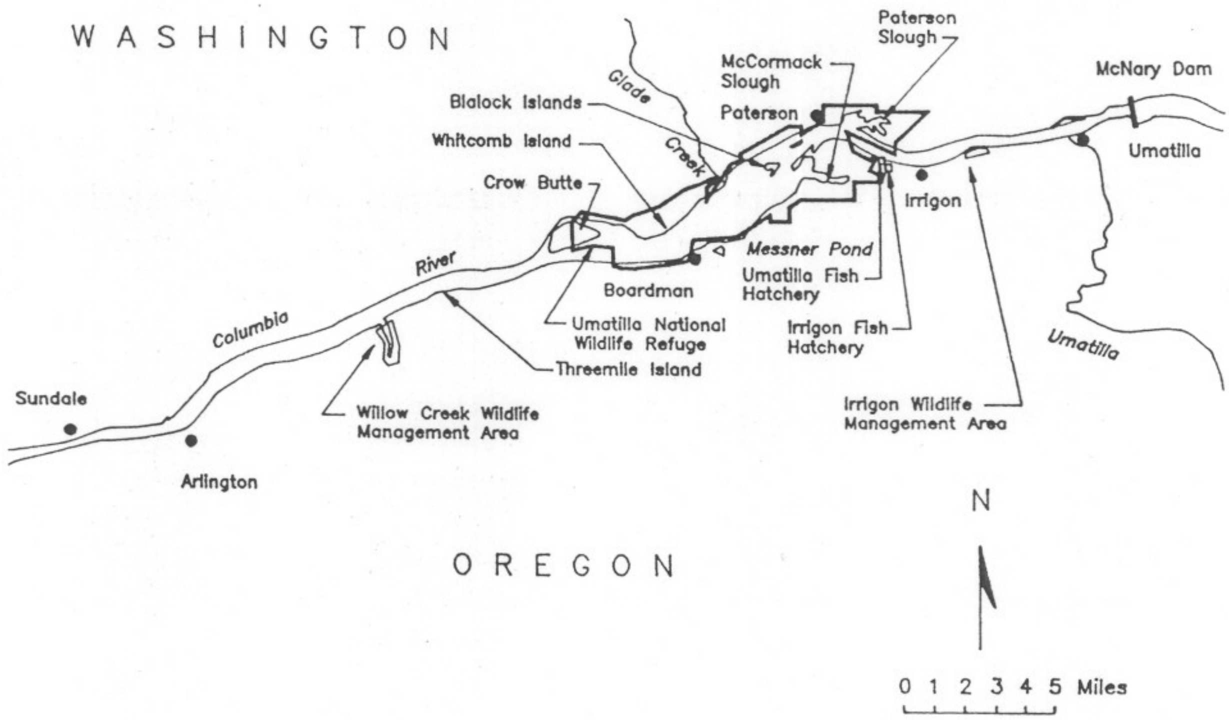

Figure 1. Map of the Umatilla National Wildlife Refuge showing sampling sites at Three-mile Island, Crow Butte, McCormick Slough, Glade Creek, and Cold Springs.

Local plant communities are predominantly shrub-steppe and grasses, with riparian areas near the river. Big sagebrush and rabbitbrush are the most common shrub species. Common riparian vegetation include willows, false indigo, black cottonwood, Russian olive, and alder. Most of the wildlife refuge is undisturbed, but approximately 1,500 acres are farmed. The growing season is 200 days, and the average temperature is 53°F. Local climate is typical high desert, with hot days and cool nights. It will frequently reach 100+°F in summer and -5°F in winter. Annual precipitation is only 6-7 inches, and high winds occur frequently in spring and early summer. The soils are dominated by sand or loamy-sand.

Most of the refuge water is in or associated with the Columbia River. In this stretch of the river, elevations are shallow and backwaters and ponds average 2-4 feet deep. Refuge water levels fluctuate as the John Day Pool is adjusted for irrigation or navigation purposes. Ground water is pumped from wells for domestic or irrigation purposes. Ground and surface water runoff flow is through the refuge down to the Columbia River.

The refuge is managed primarily for wintering waterfowl; however, several species of birds use the refuge for nesting during spring and summer. Most of the refuge is open to public uses, both consumptive and non-consumptive recreation occurs at various times of the year. The refuge is used for hunting, fishing, boating, hiking, photography, environmental education, wildlife observation, and aesthetic purposes.

Agricultural Practices

The refuge was established at approximately the same time as the inception of center pivot irrigation in the local area. The refuge is almost completely surrounded by and downslope from irrigation "circles", and there are now hundreds of irrigated farm circles in the local farm community. Local farm practices can be considered nearly-hydroponic. Almost all of the soils are sand or loamy sand and require heavy irrigation. Almost all nutrients/fertilizers are supplied through irrigation systems, and nearly all pesticides are applied in a similar fashion.

Three of the five designated critical ground water areas in Oregon are located in the vicinity of the refuge and were so designated because of excessive and sustained drop in localized water table elevation caused by extensive irrigation pumping. The State Water Resources Department has terminated new well drilling since monitoring has revealed ground water elevation decreases from 80 to as much as 250 feet. Some areas adjacent to the refuge are suffering high nitrate loading in the ground water systems because of extensive fertilizer use in the area. Several farm-based nitrate leaching studies are being conducted by the Oregon State University Agricultural Experiment Station.

Local crops are primarily potatoes, corn, onions, watermelons, alfalfa, and small grains (wheat, corn, canola). Recently, some crop diversity is creeping in to the area, and more row crops and fruits are being planted. Pesticides are heavily used on the crops grown in this area. Most pesticides used today are organophosphate and carbamate based, but historically, several organochlorine based pesticides were used including heptachlor, DDT, and endrin. In the mid-1970's, the area lost about a third of the nesting population of Canada geese due to the use of heptachlor as a wireworm preventative (Blus et al. 1979). Die-offs of gulls have occurred in two different instances from pesticide mishandling.

The wildlife refuge has 10 circles under agricultural production. These total about 1,500 acres. Until 3 years ago, these were farmed in the 'typical' local practices; high application rates of both pesticides and fertilizers (table 1). A common crop rotation on the refuge was potatoes, corn, and wheat. These crops required a strict regime of pesticides heavily based on organophosphate and carbamate compounds. For example, chemicals applied to potatoes in 1986 included Ambush, Botram 75-W, Captan, Eptam, Lexone, Maneb, Monitor 4, Phorate 15-G, Pounce, Prowl, Pydrin, Sencor 4, Temick 15-G, and Vapam.

Today, the refuge is phasing out most pesticides and a large portion of chemical fertilizer, and is progressing toward an organic farm program. They have eliminated some crops that required extensive pesticide use (e.g. potatoes). Dominant crops now grown on the refuge include organic alfalfa, canola, carrots, and peas; plus kubochi squash, sordan grass, and wheat.

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Table 1. Pesticides used on the Umatilla National Wildlife Refuge in 1986.

PESTICIDE	FARM CROP OR AREA	TARGET PEST OR USE
Ambush	Potatoes	Insects
Atrizine 4-L	Corn	Weeds
Banvel	Wheat	Broadleaf weeds
Botran 75-W	Potatoes	Sclerotemia blight
Captan	Potatoes	Soft rot
Chem-Hoe FL4	Barley, Alfalfa	Grass
2,4-D amine-4, ester	Wheat, Poco, Barley, Corn, Oats	Broadleaf weeds, Weeds
Diazinon	Squash	Cutworms, Insects
Eptam	Potatoes	Weeds, Corn
Eradicane	Corn	Weeds
Kerb 50-W	Alfalfa	Grass
Krovar 1	Roadsides, Parking lots	Weeds
Lexone	Alfalfa, Potatoes	Weeds
Maneb	Potatoes	Fungus
Mocap	Potatoes	Wireworms, Nematodes
Monitor 4	Potatoes	Aphids, Cut worm, Aphids, Colorado Potato beetle,
Phorate 15-G	Potatoes	Beetles, Worms
Pounce	Potatoes	Weeds
Pro-Cure	Alfalfa	Drying Agent
Prowl	Potatoes	Weeds, Grass
Pydrin	Corn, Potatoes, Squash	Worms, Beetles
Ridomil	Potatoes	Fungus
Rodeo	Aquatic marshes	Purple loosestrife
Round-up	Potatoes, Alfalfa, Bee hives, Buildings	Weeds, Grass
Sencor 4	Potatoes, Alfalfa	Weeds, Grass
Sim-Trol 4-L	Bee hives	Weeds
Surflan	Alfalfa, Bee hives	Weeds
Strychnine 1-10	Fields	Pocket gophers
Temick 15-G	Potatoes	Nematodes, Aphids
Thimet 20G	Potatoes	Beetles, Aphids
Treflan	Potatoes, Squash	Weeds
Vapam	Potatoes	Nematodes
Velpar 4-L	Alfalfa	Broadleaf weeds

Fish and Wildlife Resources

Umatilla National Wildlife Refuge is primarily a waterfowl area. The area attracts large numbers of mallard, American wigeon, pintail, green-winged teal, and Canada geese. Waterfowl numbers are highest during winter months but large numbers of birds also use habitat for resting and feeding during spring and fall migration. It is common to find 400,000 ducks and 60,000 geese in or near the refuge in winter. Several species of ducks and a large number of Canada geese, numbering 350 pairs, nest on the refuge in spring and summer.

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Large numbers of waterbirds occur along the river. Gulls, terns, herons, and also shorebirds number in the thousands during peak periods. California and ring-billed gulls, Caspian and Forsters' terns, and great blue and black-crowned night herons nest in colonies on islands in the Columbia River. Black-crown night heron populations are very low and are listed as a species of special concern by the State of Oregon. The refuge and areas along the Columbia River are also used by several species of shorebirds including American coot, killdeer, spotted sandpiper, and black-necked stilt.

The refuge supports a winter population of bald eagles (listed as threatened under the Endangered Species Act); and also plays host to peregrine falcons (listed as endangered under the Endangered Species Act) during the spring and fall migration periods. Eagle numbers vary from 25 to 95, and falcons are observed only a couple times per year.

The refuge uplands support abundant populations of ring-necked pheasants, California quail, and mourning doves. Several species of raptors and passerines may be found locally and are known to nest on the refuge. The local vicinity, as well as the refuge, is famous for its populations of burrowing owls and the long-billed curlews, both of which nest there.

The refuge supports nearly 200 mule deer throughout most of the year. The deer use the islands in the Columbia River for fawning. The refuge also supports a variety of other mammals including coyotes, badgers, beaver, muskrat, mink, river otter, skunk, raccoons and an occasional bobcat.

The Columbia River, as it passes through the wildlife refuge, provides a migratory corridor for anadromous fish, including chinook, coho, and sockeye salmon; steelhead trout; white sturgeon; American shad; and Pacific lamprey. The river is vital for passage of adult salmonids to spawning and rearing waters in the upper Columbia and Snake River systems and juvenile salmonids migrating to the ocean. The Columbia River also has abundant numbers of resident species such as walleye, largemouth and smallmouth bass, rainbow trout, whitefish, bullhead, black and white crappie, yellow perch, channel catfish, squawfish, suckers, common carp, and sculpin. Shallow, backwater areas on the refuge, including Paterson and McCormick Sloughs, provide vital spawning and rearing habitat for several warmwater game fish.

SAMPLE COLLECTION AND ANALYSIS

Sampling sites were selected to represent habitats where irrigation drainage could have an impact on fish and wildlife. Sampling areas included stream habitat, irrigation drainage ditches, open water sloughs, and shallow lakes. Samples were collected from four sites during July through September 1989. Sample sites included Cold Springs, Crow Butte, Glade Creek, and McCormick Slough (figure 1). Since bird eggs were not available from any of these sites, eggs of gulls were collected from Three Mile Island (figure 1).

Only one sample of each matrix type was collected from each site, because of the pre-reconnaissance nature of this study. Sample matrices included surface water, bottom sediments, aquatic plants, aquatic invertebrates, fish, and birds. Biota species collected included water strider, sago pondweed (*Potamogeton pectinatus*), common carp, mosquito fish, bullhead, mallard, red-winged blackbird, and ring-billed gull eggs. Not all samples were available at every sampling site. Sago pondweed was found only at Crow Butte, bullheads and carp only at Cold Springs and McCormick Slough, mosquito fish only at Glade Creek, gull eggs only on Three-mile Island, mallards only at Crow Butte, and red-winged blackbirds only at McCormick Slough.

Water samples were collected in chemically cleaned glass bottles. Samples collected for inorganic analyses were buffered with nitric acid (2 ml) to a pH of $\leq$2.0. Sediment samples were collected with a stainless steel Ekman dredge. A minimum of three subsamples were collected at each site. The subsamples were composited and mixed thoroughly using stainless-steel instruments. Samples were sieved through a stainless-steel sieve with a 2 mm (millimeter) mesh screen.

Aquatic plants and invertebrates were collected by hand and insect samples were collected with nets and separated from vegetation. Samples consisted of a composite of individuals. Fish were collected with gill nets and hook and line. A minimum of three fish were composited in each sample and were analyzed as whole-body samples. Bird eggs were collected from nesting colonies on Three-mile Island. Individual eggs were weighed and measured prior to being composited (3 eggs/sample). Adult birds were collected with a shotgun and steel shot. The livers were used for inorganic analyses and carcass for organic analyses. The feathers, feet, bills, and gastrointestinal tracts were removed from the carcass prior to chemical analysis. The gastrointestinal tract was used for organophosphate and carbamate pesticide analyses.

Except for samples of fish and bird carcasses, which were wrapped in aluminum foil and placed in plastic bags, all other samples were stored in chemically cleansed jars (washed and rinsed with acetone and hexane). Immediately after collection, samples were temporarily chilled then stored at freezing (-13°C) for 3 to 5 months prior to chemical analysis. Water samples were refrigerated at 4°C until analyzed.

Surface water, sediment, and biota samples were analyzed for selected inorganic (Appendix I) and organic compounds (Appendices II and III). Four water samples were analyzed for trace elements and five water samples were analyzed for organochlorine compounds, organophosphate and carbamate pesticides, and chlorophenoxy acid herbicides. Four sediment samples were analyzed for trace elements and organochlorine compounds, and five sediment samples were analyzed for organophosphate and carbamate pesticides. Fourteen biological samples were analyzed for trace elements, 12 biological samples were analyzed for organochlorine compounds, and four biota samples for organophosphate and carbamate pesticides. Trace element analyses were performed by Environmental Trace Substances Research Center, Columbia, Missouri; Mississippi State Chemical Laboratory, Mississippi State, Mississippi completed the analyses for organochlorine pesticides, PCBs, and chlorophenoxy acid herbicides; and analyses for carbamate and organophosphate pesticides were performed by the Patuxent Analytical Control Facility, Laurel, Maryland. Quality assurance-quality control was done by the U.S. Fish and Wildlife Service, Patuxent Analytical Control Facility to ascertain accuracy and consistency in analytical results.

Toxicity tests were performed by the Minnesota Cooperative Fish and Wildlife Research Unit, University of Minnesota. Toxicity tests were used to biologically assess the presence of hazardous concentrations of contaminants. Water-borne toxicity was evaluated using a 48-hour, static, nonrenewal larval *Daphnia magna* bioassay; a 96-hour, static, nonrenewal larval fathead minnow (*Pimephales promelas*) bioassay; and a microbial bioassay (Microbics Corporation). Bulk-sediment toxicity was assessed using a 48-hour, static, nonrenewal larval *Chironomus tentans* bioassay. Test conditions and specifications followed U.S. Environmental Protection Agency (1985) and American Society for Testing and Materials (1989) guidelines and are described in Henry et al. (1992).

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RESULTS AND DISCUSSION

Trace Elements

Concentrations of trace elements detected in water collected from four sites on the Umatilla NWR are reported in table 2. In addition to those elements listed, water samples were analyzed for cadmium, mercury, and thallium but showed no detectable levels (Appendix I). Most elements detected in refuge waters, with the exception of iron and lead, were well below U.S. Environmental Protection Agency (1992) acute and chronic criteria for protection of aquatic life. Concentrations of iron exceeded chronic criteria at three sites and lead exceeded chronic criteria at four sites.

Table 2. Trace element concentrations in water collected from Umatilla National Wildlife Refuge, 1989. [Concentrations are in micrograms per liter (µg/L); -- + not available]

Element	Water Concentrations				Criteria[a]	
	Cold Springs	Crow Butte	Glade Creek	McCormck Slough	Acute	Chronic
Aluminum	3900	140	1980	82	--	--
Arsenic	2.2	8.4	1.8	3.4	360	190
Beryllium	<0.1	<0.1	0.1	<0.1	--	--
Chromium	5.3	<0.3	4.6	1.0	1700[b,c]	210[b,c]
Copper	5.4	0.8	5.2	0.6	18[c]	12[c]
Iron	5070	492	3650	1470	--	1000[d]
Lead	10	5.0	10	8.0	82[c]	3.2[c]
Manganese	552	6.8	93.6	172	--	--
Nickel	3.0	3.0	4.6	1.0	1400[c]	160[c]
Selenium	<0.3	1.0	0.7	0.4	20	5
Zinc	51.8	4.4	19	7.7	120[c]	110[c]

[a] Sources: U.S. Environmental Protection Agency, Water Quality Standards, 1992.
[b] Trivalent Chromium
[c] Hardness Dependent Criteria (100 mg/L as $CaCO_3$)
[d] Source: Oregon Department of Environmental Quality, Oregon Administrative Rules, 1991.

Concentrations of iron exceeded chronic criteria at two of the three sites and were at least 3.5 times the levels established for protection of aquatic life. Lead concentrations in water at all four sites exceeded chronic criteria and concentrations shown to adversely affect daphnid reproduction (1.0 µg/L) and rainbow trout survival (3.5 µg/L) [Eisler 1988a]. However, the form of lead detected in Umatilla NWR samples is unknown and may or may not be bioavailable to fish and wildlife. Because lead in water is most soluble at low pH, low organic content, low concentrations of suspended sediments, and low concentrations of the salts of calcium, iron, manganese, zinc, and cadmium, it is not considered to be very soluble in water except in areas of local point source discharges (Eisler 1988a).

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Trace element concentrations found in sediments collected at the Umatilla NWR are given in table 3. In addition to those elements listed in table 3, sediments were analyzed for mercury, molybdenum, silver, and thallium, but concentrations were below the analytical reporting limits (Appendix I). Sediment concentrations were compared to the following guidelines: 1) Ontario Ministry of the Environment proposed Provincial

Table 3. Comparison of trace element concentrations found in sediments collected from Umatilla National Wildlife Refuge in 1989 with sediment guidelines. [Concentrations are in micrograms per gram (µg/g) dry weight; -- = not available; McCor = McCormick]

	Umatilla Sediments				Comparison Guidelines			
Element	Cold Springs	Crow Butte	Glade Creek	McCor Slough	Ontario LEL[a]	Long & Morgan ER-L[b]	EPA Heavy Polltd[c]	U.S. Mean[d]
Aluminum	17,100	20,300	17,400	14,800	--	--	--	66,000
Arsenic	2.9	7.5	9.9	3.9	6	33	>8	--
Barium	151	149	168	170	--	--	>60	554
Beryllium	0.59	0.66	0.63	0.49	--	--	--	1
Boron	<2.0	<2.0	2.0	3.0	--	--	--	34
Cadmium	<0.3	<0.3	0.30	0.30	0.6	5	>75	--
Chromium	15	17	18	15	26	80	>75	53
Copper	16	21	20	18	16	70	>50	25
Iron	25,600	26,200	27,700	25,300	--	--	>25,000	25,000
Lead	9.0	10	10	10	31	35	>60	20
Manganese	404	392	480	597	460	--	>500	560
Magnesium	4,810	6,330	7,830	5,580	--	--	--	9,200
Nickel	12	14	15	14	16	30	>50	20
Selenium	<0.1	1.9	1.4	0.3	--	--	--	--
Strontium	43.3	122	113	118	--	--	--	240
Vanadium	44.8	51.1	58.1	51.4	--	--	--	76
Zinc	53.8	58.2	60	60.6	120	120	>200	54

[a] Lowest Effect Level (LEL) Guideline established by Ontario Ministry of the Environment (Persuad *et al.* 1991).
[b] Effect Range-Low (ER-L) for NOAA's Status and Trends Program (Long and Morgan 1990).
[c] Heavily Polluted classification of Great Lakes harbor sediments (U.S. Environmental Protection Agency 1977).
[d] National average of elemental concentrations in surficial materials throughout the conterminous United States (Shacklette *et al.* 1971).

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Sediment Quality Lowest Effect Level, a level which can be tolerated by the majority of benthic organisms (Persaud *et al.* 1991); 2) National Oceanic and Atmospheric Administration's National Status and Trends Program Low Effect Range, a concentration at the lower 10% of the range in which effects had been observed in aquatic biological resources (Long and Morgan 1990); 3) the U.S. Environmental Protection Agency (1977) sediment pollution classifications; and 4) National averages found in surficial materials within the conterminous United States (Shacklette *et al.* 1971).

Concentrations detected in Umatilla sediments collected at the four sites are generally below the guidelines used for comparison. Elements which exceeded comparison guidelines were arsenic, barium, copper, iron, and manganese. Exceedances were slight and fell within the variances noted among guideline values, indicating that only very sensitive benthic species are likely to be impacted. Zinc levels in three sediment samples surpassed the National mean but did not surpass the other effect level guidelines.

Analytical results of biological samples collected from the refuge are reported in table 4 for plants, invertebrates, and fish and table 5 for birds. Concentrations found in plants, invertebrates, and fish were compared with published studies on dietary doses shown to affect higher level trophic species or concentrations in tissue associated with adverse affects in fish. Concentrations detected in bird tissues were compared with levels associated with deleterious impacts in published literature.

Table 4. Trace element concentrations in plants, invertebrates, and fish collected from Umatilla National Wildlife Refuge, 1989. [Concentrations are in micrograms per gram (µg/g) dry weight; NA = not analyzed; Mosq = Mosquito]

	Sago Pondweed	**Water-Strider**	**Common Carp**		**Bullhead**	**Mosq fish**
Element	Crow Butte		Cold Springs	McCormick Slough	Cold Springs	Glade Creek
Aluminum	986	NA	41.9/107	139/25	228	303
Arsenic	5.2	0.4	0.3/0.3	0.3/0.5	<0.2	0.67
Beryllium	0.02	NA	<0.01/<0.01	<0.01/<0.01	0.01	0.02
Cadmium	0.13	NA	0.69/0.50	0.12/0.11	<0.03	0.12
Chromium	2.5	NA	1.5/3.8	2.6/7.3	1.5	3.9
Copper	4.17	NA	5.63/5.84	5.58/4.61	4.08	4.92
Iron	909	NA	238/289	345/169	382	480
Lead	0.6	NA	<0.4/<0.4	<0.4/<0.4	<0.4/<.4	ND
Manganese	60.1	NA	11.2/18.9	16.4/11.1	29.2	20.2
Mercury	0.01	NA	1.4/1.1	0.21/0.24	0.51	0.11
Nickel	1.6	NA	1.1/2.1	1.6/3.6	0.94	2.3
Selenium	1.8	2.5	1.3/1.2	1.1/0.81	0.84	1.3
Zinc	12.7	NA	447/330	333/265	57.6	145

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Comparisons indicate that levels of arsenic (Eisler 1988b, Oladimegi *et al.* 1984); cadmium (Cain *et al.* 1983, Eisler 1985a); chromium (Eisler 1986a, Heinz and Haseltine 1981); copper (Clausen and Wolstrup 1978); lead (Eisler 1988a, Franson *et al.* 1983); selenium (Eisler 1985b, Ohlendorf *et al.* 1986, Ohlendorf *et al.* 1988a); and zinc (Eisler 1993) are not associated with impacts to fish or bird populations. Mercury concentrations detected in 3 carp samples and 1 bullhead sample are greater than the level (0.10 µg/g wet weight) recommended by Eisler (1987) to protect sensitive avian species that regularly consume fish and other aquatic organisms. Mercury residues were also detected in bird egg and liver samples from the refuge but at concentrations below those associated with adverse affects (Eisler 1987). Because no mercury was detected in water or sediments collected from the refuge, fish and birds may have accumulated it from a different area or localized source.

Table 5. Trace element concentrations in bird egg and tissues collected from Umatilla National Wildlife Refuge, 1989. [Concentrations are in micrograms per gram (µg/g) dry weight]

	Ring-billed Gull (egg)	**Mallard (liver)**	**RW Blackbird (liver)**
Element	Three Mile Island	Crow Butte	McCormick Slough
Aluminum	3.1/3.1	5.1/4.9	20/2.1
Arsenic	<0.1/<0.1	0.2/0.2	0.1/<0.1
Beryllium	<0.01/<0.01	<0.01/<0.01	<0.01/<0.01
Cadmium	<0.03/<0.03	1.4/3.2	0.42/0.27
Chromium	3.7/0.55	0.42/0.38	0.72/0.79
Copper	3.1/3.23	85.4/120	19/20
Iron	120/106	4,720/3,640	1,650/2,050
Lead	<0.04/<0.04	0.6/0.6	<0.5/<0.5
Manganese	1.8/1.6	16.6/10.7	5.01/3.88
Mercury	0.32/0.13	0.66/0.17	0.12/0.13
Nickel	2/0.3	<0.2/0.3	<0.1/<0.1
Selenium	2.2/1.2	3.1/3.7	3/3.7
Zinc	58.6/65.6	127/98.1	68.7/75.8

Organochlorine Compounds

Fourteen organochlorine compounds were analyzed in water, sediments, and biota. Concentrations of organochlorine compounds in water and sediment samples were all below their analytical reporting limits (Appendix II). A limited number of composite biota samples were analyzed for organochlorine compounds and included one plant, one aquatic invertebrate, five fish, two bird egg, and four bird carcass samples. Concentrations of organochlorine compounds in the plant and invertebrate samples were below the analytical reporting limits. Eleven compounds were detected in fish, bird egg, and bird carcass samples (table 6), most at or below the analytical reporting level

(<0.01 $\mu g/g$). Concentrations of DDE (a metabolite of DDT) was the only compound elevated in fish samples, but concentrations were lower than the 1980-81 national baseline from the National Pesticide Monitoring Program (Schmitt *et al.* 1985).

Concentrations of DDE, PCBs, and dieldrin were the only compounds elevated in bird tissue samples (table 6). DDE was found in all the bird samples analyzed, including both egg and carcass tissues. The highest concentrations were found in ring-billed gull eggs collected from Three-Mile Island. DDE concentrations in these eggs were below levels of 8 $\mu g/g$ associated with impaired reproduction (Custer *et al.* 1983, Henny *et al.* 1984, Ohlendorf *et al.* 1988b). Ring-billed gull eggs had slightly elevated concentrations of dieldrin (table 6). However, the concentrations were below concentrations observed to affect bird survival or productivity (Heinz and Johnson 1981, Mendenhall *et al.* 1983).

PCBs were detected in all ring-billed gull eggs and in one mallard carcass sample (table 6). Concentrations were relatively low and were below levels associated with lethal or sublethal effects in birds (Custer and Heinz 1980, Eisler 1986b, Heinz *et al.* 1984, Hoffman *et al.* 1986, Lowe and Stendell 1991).

Organophosphate/Carbamate/Chlorophenoxy Acid Compounds

The pre-reconnaissance nature of this study limited the analysis of pesticides to only a few water, sediment, and biota samples. Surface water from five sites, bottom sediment from four sites, and esophageal contents of two mallards and red-winged blackbirds were the only samples analyzed for organophosphate and carbamate pesticides. All pesticides analyzed in these samples were at levels below their analytical reporting limits (Appendix III).

Six chlorophenoxy acid herbicides were analyzed in five water, four sediment, and one plant sample. All herbicides were found at levels below the analytical reporting limits (Appendix II), with the exception of silvex in one sediment and one plant sample and dichlorprop in one plant sample. However, these concentrations were only slightly above analytical reporting limits of 0.01 $\mu g/g$.

Toxicity Tests

Toxicity tests were used as a screening tool to ascertain the presence of toxic compounds and whether further testing is warranted. Four toxicity tests were implemented to biologically assess the presence of contaminants (Henry *et al.* 1992). Five water and sediment samples were tested from three sites on the refuge. Sampling sites were selected that could serve as a migratory pathway for pesticides applied to agricultural fields or could be an endpoint for drainwater as it drains into a larger body of water. Water samples were tested in a *Daphnia magna* toxicity test, larval fathead minnow toxicity test, and microbial bioassay. Bulk-sediment samples were tested in a larval *Chironomus tentans* bioassay. No significant mortality or reduction in mobility was observed in *C. tetans* exposed to Umatilla sediments, or in *D. magna* and fathead minnows exposed to water samples (Henry *et al.* 1992). No significant reduction in microbial luminescence was observed following exposure to Umatilla water samples (Henry *et al.* 1992).

Table 6. Concentrations of selected organochlorine compounds in fish, bird egg, and bird tissue samples collected from the Umatilla National Wildlife Refuge, 1989. [Concentrations in micrograms per gram (μg/g) on a wet weight basis; Sl = slough; RB = ring-billed gull; Is = Island; Hepta Epox = Heptachlor epoxide; HCB = Hexachlorobenzene]

Element	Organochlorine Compounds (μg/g wet weight) in Biota					
	Common Carp		Bullhead	RB Gull Eggs	Mallard	RW Blackbird
	Cold Springs	McCormick Sl	McCormick Sl	Three-mile Island	Crow Butte	McCormick Sl
	0.02/0.04	0.01/0.01	0.01	0.02/0.02	<0.01/<0.01	0.01/<0.01
Chlordane (Γ)	0.03/0.04	<0.01/<0.01	0.01	<0.01/<0.01	<0.01/<0.01	<0.01/<0.01
DDD (p,p')	<0.01/0.01	<0.01/<0.01	<0.01	<0.01/<0.01	<0.01/<0.01	<0.01/<0.01
DDE (p,p')	0.07/0.16	0.04/0.06	0.04	0.73/3.3	0.41/0.08	0.38/0.37
Dieldrin	0.01/0.01	<0.01/<0.01	<0.01	0.05/0.27	<0.01/<0.01	0.01/<0.01
Hepta. Epox.	0.04/0.04	<0.01/<0.01	0.03	0.04/0.10	<0.01/<0.01	0.01/0.03
HCB	0.01/0.01	<0.01/<0.01	0.01	0.02/0.02	<0.01/<0.01	<0.01/<0.01
Lindane (Γ)	0.01/0.01	<0.01/<0.01	<0.01	<0.01/<0.01	<0.01/<0.01	<0.01/<0.01
Non-achlor (c)	0.01/0.02	<0.01/<0.01	<0.01	<0.01/<0.01	<0.01/<0.01	<0.01/<0.01
Non-achlor (t)	0.02/0.04	0.01/0.01	0.01	0.03/0.03	0.01/<0.01	0.02/0.08
Oxychlordane	<0.01/0.01	<0.01/<0.01	<0.01	0.02/0.07	<0.01/<0.01	0.03/0.08
PCBs (total)	<0.05/<0.05	<0.05/<0.05	<0.05	0.38/0.15	0.11/<0.05	<0.05/<0.05

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SUMMARY AND CONCLUSIONS

Water, sediment, and biological samples were collected from four sites on and near the Umatilla National Wildlife Refuge during the spring and summer of 1989. Samples were analyzed for selected inorganic and organic compounds. Water and sediment samples were also tested in bioassays to evaluate the presence of toxic compounds.

Concentrations of trace elements detected in water, sediments, and biological tissue from the refuge were generally below established criteria levels, guidelines, and published effect levels. With the exception of mercury in fish tissue, the few elements which showed exceedances were not sufficiently elevated to cause concern for fish and wildlife. Mercury concentrations in several fish samples exceeded levels recommended for protection of sensitive avian species with a diet composed largely of fish. The source of mercury in the fish does not appear to be the collection sites on the refuge since no mercury was detected in water or sediment samples.

Concentrations of most organochlorine, organophosphate, carbamate, and chlorophenoxy acid compounds were at or below analytical reporting limits. A few organochlorine compounds were slightly elevated, including DDE, PCBs, dieldrin, but concentrations were below published effect levels.

Results of toxicity tests on water and sediments support results found in chemical analyses. No significant mortality or effects were observed in toxicity tests with *Daphnia magna*, larval fathead minnow, microbial bacteria, and *Chironomus tentans*. However, toxicity due to pulses of short-lived organophosphate, carbamate, or pyrethroid pesticides could easily be missed by testing only one sample collection period.

The pre-reconnaissance nature of this study did not allow for intensive investigation and in most cases only one sample could be analyzed from each site. These limited results make it difficult to draw conclusions about whether irrigation drainwater has or will affect fish and wildlife. However, the results from this study do not show the presence of hazardous concentrations of inorganic or organic compounds. The extensive use of pesticides near the Umatilla National Wildlife Refuge could pose a continued hazard to fish and wildlife. Further and more extensive testing would be needed to determine if pesticide use poses a significant threat to fish and wildlife.

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APPENDIX I

Analytical reporting limits for selected elements in water, sediments, and biota collected from the Umatilla National Wildlife Refuge, 1989. [Concentrations are in micrograms per liter (μg/L) in water and micrograms per gram (μg/g) in sediments and biota; NA = not analyzed]

Element	Analytical Reporting Limit		
	WATER (µg/L) wet weight	SEDIMENT (µg/g) dry weight	BIOTA (µg/g) dry weight
Aluminum	3.0	3.0	0.4
Arsenic	0.3	0.1	0.2
Barium	NA	0.1	NA
Beryllium	0.1	0.1	0.01
Boron	NA	2.0	NA
Cadmium	0.3	0.3	0.04
Chromium	1.0	1.0	0.1
Copper	0.3	0.3	0.05
Iron	1.0	10.0	1.0
Lead	5.0	5.0	0.6
Magnesium	NA	2.0	NA
Manganese	0.3	0.4	0.06
Mercury	0.3	0.02	0.05
Molybdenum	NA	3.0	NA
Nickel	1.0	2.0	0.2
Selenium	0.3	0.1	0.2
Strontium	0.3	0.1	NA
Thallium	8.0	6.0	0.8
Vanadium	NA	0.3	NA
Zinc	0.4	0.4	0.08

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APPENDIX II

Analytical reporting limits for selected organochlorine compounds and chlorophenoxy acid herbicides in water, sediments, and biota collected from the Umatilla National Wildlife Refuge, 1989. [DDD = dichlorodiphenyldichloroethane; DDE = dichlorodiphenyl-dichloroethylene; DDT = dichlorodiphenyltrichloroethane; PCB = polychlorinated biphenyl; 2,4-D = 2,4-dichlorophenoxyacetic acid; 2,4,5-T = 2,4,5-trichlorophenoxyacetic acid; NA = not analyzed; Concentrations are in micrograms per liter (μg/L) for water, micrograms per gram (μg/g) for sediments and biota]

Compound	Analytical Reporting Limit		
	WATER (μg/L) wet weight	SEDIMENT (μg/g) dry weight	BIOTA (μg/g) dry weight
	0.005	0.01	0.01
DDD	0.005	0.01	0.01
DDE	0.005	0.01	0.01
DDT	0.005	0.01	0.01
Dieldrin	0.005	0.01	0.01
Endrin	0.005	0.01	0.01
Heptachlor Epoxide	0.005	0.01	0.01
Hexachlorobenzene	0.005	0.01	0.01
Lindane (BHC)	NA	0.01	0.01
Mirex	0.005	0.01	0.01
Nonachlor	0.005	0.01	0.01
Oxychlordane	0.005	0.01	0.01
Total PCBs	0.005	0.05	0.05
Toxaphene	0.005	0.05	0.05
<u>Chlorophenoxy Acid</u>			
Dicamaba	0.005	0.01	0.01
Dichlorprop	0.005	0.01	0.01
Silvex	0.005	0.01	0.01
2,4-D	0.005	0.01	0.01
2,4,5-T	0.005	0.01	0.01
2,4-DB	0.005	0.01	0.01

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APPENDIX III

Analytical reporting limits for selected carbamate and organophosphate pesticides in water, sediments, and biota collected from the Umatilla National Wildlife Refuge, 1989. [Concentrations are in micrograms per liter (μg/L) for water and micrograms per gram (μg/g) for sediments and biota]

Compound	Analytical Reporting Limit		
	WATER (μg/L) wet weight	SEDIMENT (μg/g) dry weight	BIOTA (μg/g) dry weight
Carbamate Pesticides			
Aldicarb	0.02	1.0	1.0
Carbaryl	0.02	1.0	1.0
Carbofuran	0.02	1.0	1.0
Methiocarb	0.02	1.0	1.0
Methomyl	0.02	1.0	1.0
Oxamyl	0.02	1.0	1.0
Organophosphate Pest.			
Acephate	0.002	0.5	0.5
Azinphosmethyl	0.002	0.5	0.5
Chlorpyrifosdursban	0.002	0.5	0.5
Coumaphos	0.002	0.5	0.5
Demeton	0.002	0.5	0.5
Diazinon	0.002	0.5	0.5
Dichlorvos	0.002	0.5	0.5
Dicrotophos	0.002	0.5	0.5
Dimethoate	0.002	0.5	0.5
Disulfoton	0.002	0.5	0.5
Dursban	0.002	0.5	0.5
EPN	0.002	0.5	0.5
Ethoprop	0.002	0.5	0.5
Famphur	0.002	0.5	0.5
Fensulfothion	0.002	0.5	0.5
Fenthion	0.002	0.5	0.5
Malathion	0.002	0.5	0.5
Methamidophos	0.002	0.5	0.5
Methyl Parathion	0.002	0.5	0.5
Mevinphos	0.002	0.5	0.5
Monocrotophos	0.002	0.5	0.5
Parathion	0.002	0.5	0.5
Phorate	0.002	0.5	0.5
Terbufos	0.002	0.5	0.5
Trichorfon	0.002	0.5	0.5